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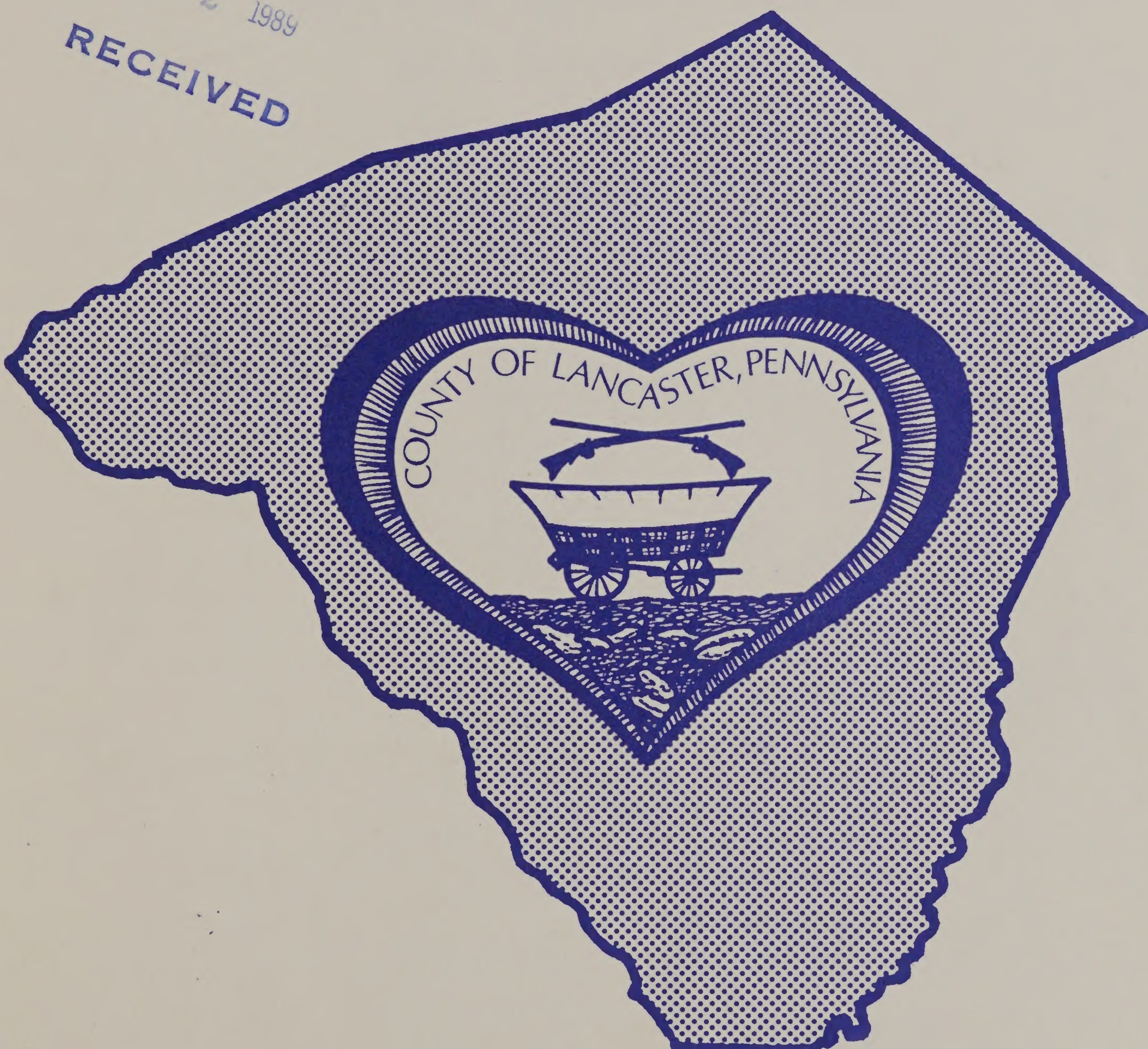
Appendix K

Lancaster Area Land & Water Resources Study

Procedures for Developing Alternative Land Use Patterns



IN COOPERATION WITH THE LANCASTER COUNTY COMMISSIONERS & THE LANCASTER CONSERVATION DISTRICT

LANCASTER AREA LAND AND WATER RESOURCE STUDY

APPENDIX K

PROCEDURES FOR DEVELOPING ALTERNATIVE LAND USE PATTERNS

PREPARED BY

UNITED STATES DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

ECONOMIC RESEARCH SERVICE

FOREST SERVICE

IN COOPERATION WITH

LANCASTER COUNTY COMMISSIONERS

LANCASTER CONSERVATION DISTRICT

ACKNOWLEDGEMENT

JOHN WENDEROTH
ECONOMIC RESEARCH SERVICE

June 1983

PREFACE

This report describes the methods and results of a group effort which began in the summer of 1981 and ended in September, 1982. This group, identified for the purposes of this study as a Task Force*, consisted of representatives of the Lancaster Chamber of Commerce and Industry, the Lancaster Conservation District, township and county government groups, and the farming community. The Soil Conservation Service and Economic Research Service also met regularly with the Task Force in an advisory capacity. The Lancaster County Planning Commission and Data Processing Department and the Economic Research Service have been responsible for technical support, especially in coding data and in operating the automated geographic information system developed to facilitate the work of this study.

As a group, the Task Force attempted to answer some very speculative questions about future land use change and its consequences for agriculture. The predictions in this report are beyond what anyone can know with great assurance and depend very much on the procedures used to produce them. Therefore, to appreciate these predictions requires an understanding of the method which produced them. This is intended both to caution and to encourage the reader.

Before reading this report, consider that the thinking used to formulate these predictions was based on <u>expectations</u> - that is, prior conceptions of these predictions which existed in the minds of those who participated in these discussions. Without these expectations, there is little basis for judging how well the results predict the future. At the same time, these expectations do not eliminate the possibility of being surprised by new insights, for the "mind's eye" does not see even its own expectations very clearly - particularly if these expectations are detailed or complex.

The maps enclosed in this report are only a first attempt to construct images of the future for Lancaster County. These are subjective images formed by discussion of relevant issues. Understanding the meaning of these images depends on knowing the choices that were made in forming them. Reflecting on their meaning and on these choices will guide their improvement.

*Members and participants in the work of this Task Force are acknowledged in Exhibit A at the end of this report.

We turn now to the consideration of the place of the image in the dynamics of society. We must emphasize from the first that the image is a property of the individual person. It is only by way of metaphor and analogy that we can speak of organizations or of society as a whole as possessing an image. Nevertheless, there are images of some individuals in society, and parts of the image of most individuals which can properly be regarded as an image of the society itself though the image is "in the minds of the individuals."

In thinking about the relation of images to society, we must first think of the inventory of the images of the individuals who compose the society. This may be thought of in the first instance as a simple list of the images of individuals a, b, c, etc. We next consider...

Kenneth E. Boulding
The Image, p. 54

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I - INTRODUCTION

One objective of the Lancaster Area Land and Water Resources Study is to understand certain aspects of the competition for land presently used for agricultural purposes in Lancaster County, Pennsylvania (Figure 1). As one contribution to that objective, this report demonstrates how two closely-related questions about the spatial implications of land use competition can be answered:

1) Where is land use change expected to occur in the agricultural areas of Lancaster County?

2) Will these anticipated changes produce "conflicts" over the use of agricultural land?

In the future, the farmland of Lancaster County will occupy less area than it does now. Competition among alternative uses is accepted as a major determinant of this change. The major role played by competition in causing land use change is an underlying premise of the method described in this report. Competition for land, primarily for urban use, will directly or indirectly account for the loss of land now used for agricultural purposes.

Another way to view this competition is to see every parcel of farmland as a potential site for the next housing development, the next shopping center, or the next industrial park. This potential is reflected in the relatively high value of agricultural land in Lancaster County. This value must be attributed to more than the discounted value of all future agricultural production. When one pays more than the pure agricultural value for an acre of farmland today, he is paying for more than all the corn, cattle, or other farm products he might ever derive from that land; he is also paying to preserve a tradition or to speculate on the future value of that land for other competing uses. Because the amount of land needed for new development each year is only a small part of all land that is actually available, each parcel of land competes with all others to attract this limited annual increment of new development.

The first part of the method described in this report explores the geographic variation in land quality for agriculture and for each of three urban (non-agricultural) uses. This aspect is an attempt to capture those characteristics of land which give it a competitive advantage for each of the four possible uses. This also establishes the basis for exploring the future interactions of these four uses.

Using an "ability to pay for land" concept, the second part of the method described here is intended to examine the implication of the separate use evaluations by merging anticipated amounts of new development with the current agricultural area. Generally in any competition among uses, the more intensive uses of land offer a higher price per acre. Therefore, agriculture is often relegated to the status of a residual or left-over use. This sets the stage for the third part of the method which examines the "conflict" created when agricultural land is also attractive for competitive uses. It is only in this narrow sense that conflict is explored.

Figure 1 -- Lancaster County municipalities

This report does not attempt to defend this concept of land use change or the procedures used to examine its implications. There is no intent to prescribe a particular outcome. However, the report does describe a method which may be used as a learning mechanism and as a means to anticipate change. Its assumptions are not rigid; new assumptions may be tested and old ones revised so that understanding the process and direction of change will improve. In this regard, the method has also been designed to be flexible. It should enable, guide, and improve the ability of those who use it in understanding the process of land use change and alternative possibilities for the future.

II - METHOD

Background

The method is described in the following pages to document the experience of a committee of Lancaster County residents who were a vital part of its implementation. The knowledge, values, and opinions of the members of this commmittee are an important source of subjective data for the method. This committee was consulted at regular intervals during the course of this work.*

Only a part of Lancaster County is considered in this evaluation. That portion consists primarily of pasture and cropland which covers about two-thirds of the county.** Not included are wooded areas, even though they may be a part of farm properties.

This agricultural area of the county is examined from four different points of view. Each viewpoint is based on a broadly defined land use category (Table 1). Although these categories do not encompass all possible uses of the area evaluated, they do recognize the principal activities which will compete for land.

Computer Information Retrieval

Many of the calculations required to carry out this evaluation were performed with the aid of a computer information retrieval system.*** However, understanding the method does not require knowledge of how the computer functions or how it must be programmed to produce the results shown in the following pages.

Minimum unit of information: It is helpful to know that, within the computer, the Lancaster County area is described by a grid of small cells or parcels, each square in shape and each approximately ten acres in size. It is with reference to this stationary grid of cells that data are stored, each particular variety being kept in a separate "file". After data are properly stored, they must then be retrieved from each cell which is referenced by the row and column position in the grid, much as the reader would locate a place on a road map from letter or number scales on the margins.

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*Minutes of these meetings are on file with the Lancaster County Planning Commission. The author of this report deeply appreciates the members' interest, conscientious participation, and patience.

**Approximately 424,500 acres, estimated from digitized data for land cover which was defined by the interpretation of 1978 aerial photography.

***The Lancaster County Geographic Information System (GIS) has been installed on the Lancaster County UNIVAC computer. The GIS is documented in Appendix A of the LALWRS reports. The results presented in this report were actually performed on an IBM computer at the UNI-COLL facility in Philadelphia, where a simplified form of the GIS has also been installed.

Table 1--Categories of Generalized Land Use

Category	Definition
Agricultural	-crop and animal production including farmsteads and other farm structures
Residential	-house lots for isolated or clustered development, townhouses, or multi-story apartments used for residential purposes
Commercial	-retail establishments whose business deals directly with a large segment of the public
Industrial	-industrial or manufacturing activities including transport services and warehouses

A square, four-hectare (or about 9.88 acre) grid cell is the smallest unit of the county's land area for which data can be stored or retrieved and for which new information, such as land use evaluations, can be developed. For the purpose of this report, the smallest geographic representation of land area in Lancaster County will be called a "mapel": mapel is an abbreviation for "map element". Whenever encountered, the term mapel should remind the reader that every grid cell is processed by the information retrieval system to produce any map, regardless of scale.

Transforming information into maps: The transformation of mapels into a map on the type of computer printer used by the information retrieval system can be complicated. This complication is due partly to the fact that the letters or numbers printed by the computer are not square in shape as are the mapels. In order to print maps of various scales, a transformation must be made to account for both symbol shape and map scale so that the resulting map has correct dimensions in east-west, north-south directions.*

Because of the size of a print symbol (which is about the size of a capital letter on this page) a map must be printed at approximately 1:72,000 (1 inch = 6,000 feet) scale to expose the detail stored in each mapel. At a larger scale (e.g., 1:48,000 or 1 inch = 4,000 feet), the reader would see no new detail - the map would simply occupy a larger sheet of paper and each mapel would be clearly evident as a block of print of the same symbol. At a smaller scale (e.g., 1:150,000 or 1 inch = 12,500 feet) some details would be lost. This loss is due to averaging procedures which are necessary in order for computer programs to display the content of all mapels as a map on a standard computer printer.

All of the maps included in this report were originally printed at a scale of 1:150,000 and then reduced to various sizes on a photocopy machine.** By producing a larger map and then photo-reducing it, more detail can be presented on a relatively small, page-size map. This detail is not possible if the smaller map is printed directly by the computer printer for the reasons given above.

Method Overview

The tasks described in this part of the report have been divided into three phases: the first develops quality indices, the second predicts future land use change, and the third estimates conflict among land uses. Each land use is evaluated separately by the procedures of the first phase. Thereafter, the second and third phases interrelate the independent results of the first phase to answer the questions asked in the INTRODUCTION to this report.

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*The retrieval system programs can generate maps over a wide range of scales: from 1:24,000 (1 inch = 2,000 feet) to 1:380,160 (1 inch = 6 miles).

**This compromise was made since a map four times as large (twice as large in each dimension) would have been necessary to show all the detail of a map's data file. A map of such size would have been expensive and time consuming to handle for the purposes of this report.

Table 2--Method Overview: A Summary Outline of Sequential Steps

---

A. Develop a Relative Quality Index (for each land use)

   1. Identify and select factors which are considered to be a major influence on the quality of land for a specific category of land use

   2. Rate factors as to their relative influence on the quality of land for the specific land use

   3. Refine factor definitions to permit their use in the computer information retrieval programs

   4. Calculate index values and display statistical and geographic distributions for the specific land use

   5. Review index distributions for needed adjustments (repeat steps 1 thru 4 above as required)

   6. Recalculate and display revised index values for the specific land use

   (Repeat for each land use before continuing)

B. Predict Future Land Use Patterns

   1. Define rules for merging land uses

   2. Merge land uses to form a future pattern

   3. Display map of a future land use pattern

   (Make adjustments as a result of review)

C. Estimate Conflict with Agricultural Use

   1. Define aspects of conflict examined

   2. Make decisions to determine type and location of conflict

   3. Display distribution of estimated conflict among uses

   (Make adjustments as a result of review)

The first phase is designed to assess the factors which contribute to qualitative differences in land for each of the four uses and to develop an index of relative quality for each land use based on this assessment process. The work involved in this phase is outlined as a sequence of six steps in Table 2 (part A). The important fifth and sixth steps recognize the need to review the result of the first four and to repeat any or all of these previous steps to adjust that result. The final result of this phase is a set of numerical indices (one index for each land use), which express the relative quality, from place to place, of the present agricultural area of the county. Index values for each land use are examined primarily by displaying their geographic distribution as maps.

The purpose of the second phase (Table 2, part B) is to anticipate where agricultural land may be lost due to some amount of increase in the area of each of the urban use categories. The way in which this increase is distributed through out the county is determined by defining an order of priority among uses and by establishing thresholds of acceptability, based on the quality index values estimated for each land use on each mapel during the previous phase. Note that the amount of land assigned to each urban category is <u>not</u> determined by the method described here.*

The final phase (Table 2, part C) specifically examines "conflicting pressures" on the current agricultural area. Conflict is defined for each mapel by determining what combinations of quality exist among the four uses. Higher quality is defined for each land use as exceeding a certain index value. The coincidence of higher quality among uses is the basis for designating the location and degree of conflict on a mapel-by-mapel basis.

<u>Develop a Relative Quality Index</u>

The procedure for constructing a relative land quality index is sufficiently uniform for each land use so that only the details for the agricultural use are described here. Quality indices for the three urban uses are mentioned only where they clarify this otherwise general procedure. By emphasizing a single land use in this demonstration of the construction of an actual index, the reader is reminded that the agricultural area is being examined separately for each land use. After these independent evaluations are completed, subsequent phases of this method demonstrate how the indices are merged to predict future patterns of land use and to estimate conflict.

<u>Identify and select factors</u>: The purpose of this initial step is to identify the kind of influences that are considered to make land qualitatively better for agricultural use. After a number of factors are identified, those which are considered most significant are selected as the basis for the initial estimates of the agricultural index.

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*Projections of the amount of land use change and the methods for deriving them are discussed in Chapter II of the Main Report.

Little knowledge of Lancaster County is required to identify some factors which greatly influence the quality of land for agriculture. Such factors are universal and would be appropriate in most places. Other factors are more readily identified by local residents who are more intimately familiar with the county.

Identifying factors by group discussion requires individual participants to generalize from their actual experience and to use imagination in developing additional ideas. Initially, this process is facilitated by avoiding debate. One idea produces others as each suggestion stimulates more discussion. During discussion, definitions are gradually clarified so the group functions with a common understanding of the concepts developed. The first result may be no more than a "laundry list" of unstructured expressions which have been quickly recorded to preserve ideas as they are suggested (Figure 2).

This initial list illustrates that some of the factors selected may be inherent qualities of a specific place, while others may depend primarily on the context in which the place occurs. "Soil quality" and "slope", for examples, are inherent attributes of a given site. "Farmer attitude", "zoning" and "proximity to markets" can change with time or be influenced by events or features in a particular parcel's surroundings.

Some items on this initial list reflect the idea that residual or left-over land is given to agricultural uses. "Low development value" or "flood prone areas" are two ways to express this idea. Such items are also not consistent with the intent to identify factors which make land qualitatively better for agriculture.

Still, other items recognize two sides of the same issue: consider for example how "large contiguous tracts" is related to "lack of urban intrusions". The items included may also be rather complex concepts: "farmer attitude" and "traditional commitment" are obviously relevant, even though neither is easy to define or measure.

The selection of factors for testing is then decided by debate and voting. Debate further clarifies definitions and removes ambiguity, without requiring participants to personally defend their original suggestions. As a matter of convenience, factors are limited to five (or six, in the case of other land uses) to reduce the work required in implementing the initial evaluation (Table 3).

<u>Rate factors as to their relative influence</u>: The purpose of this step is to assess the relative importance of each factor in the selected set. Some factors are simply more important than others. Assigning importance can be

Figure 2--Preliminary factors for assessing agricultural quality. This figure is a reduction of a flip chart page prepared during Task Force discussions.

AG. USES

O- AG ZONING (effective) 4

O- FARMER ATTITUDE 2 + TRADITIONAL COMM. 3 1

- SOIL QUALITY 4

- WATER AVAILABILITY - GROUND WATER 8 3

- SLOPE 2 1

~~O TRADITIONAL COMMITMENT~~ -0-

- LARGE, CONTIGUOUS TRACTS 4

- TRANSP. ACCESS 2 0

- LOW DEVEL. VALUE 0

- LACK OF URBAN INTRUSIONS 2 2

- FLOODPRONE AREAS 2 2

- PROXIMITY TO MARKETS 0

Table 3--Factors Selected for Developing Land Quality Indices

Agricultural

- Farmer attitude and traditional commitment
- Groundwater availability
- Soil quality which favors cultivation/productivity
- Zoning which supports retention of agricultural uses
- Large contiguous tracts of agricultural land

Residential

- Public sewer service
- Suitability for on-site sewage disposal
- On-site groundwater availability
- Proximity for commercial centers
- Zoning for denser development
- Public water supply service

Commercial

- Public sewer and water services (both)
- Minimal storm water problems
- Favorable zoning
- Visibility to the public
- Proximity to transportation routes
- Proximity to residential areas (population)

Industrial

- Expansion around existing facilities
- Level land (minimal slope)
- Availability of power
- Public sewer and water services (both)
- Favorable zoning
- Access to heavy transportation

done somewhat arbitrarily or can involve more careful reasoning. This step is accomplished by three tasks performed in the following sequence:

1) each participant individually ranks the factors in the order he deems appropriate

2) ranked factors for all participants are transformed mathematically into a single set of weights (one weight for each factor), which add to a predetermined total

3) all participants, through debate and voting, adjust the set of weights so that the predetermined total is unaltered.

Ranking factors by order of importance is a relatively easy task, particularly when performed individually. By reasoning privately, each participant is not subjected to the subtle coersion of dominant opinions in the group as he summarizes his intuitive judgment of the relative significance of each factor. He also embodies in that ranking his understanding of the factors, which have not been rigorously defined, and his perspective on the overall purpose for ranking them. The worksheet used in this exercise is illustrated in Figure 3.

Given that there are 120 possible ways in which to rank five factors (that is, five ways to choose the first, four ways to choose the second, etc., which produces 5 x 4 x 3 x 2 x 1 = 120), it would be surprising to find all or most of the participants to be in perfect agreement. Similarity among these rankings, to whatever degree it exists, is accepted as evidence of a commonly held or shared perception of how the factors actually influence land quality in the county. Estimates of this similarity are therefore developed to measure how well the rankings agree, even though they are somewhat different.

The transformation of individual rankings is accomplished with mathematical techniques, which are more complex than simple averaging, but which produce a preliminary estimate of each factor's relative influence.* The transformation technique relies on measuring the correlation between all pairs of individual opinions. A "compromise position" is then estimated mathematically. This compromise maximizes the contributions of all individuals in the group. As a result, the compromise determines (controls) how much each individual opinion will contribute to the final result. Those who "agree" with the compromise have a greater influence on the resulting composite opinion than those who "disagree". However, the technique is not used to dictate a final result. Its principal purposes are to better understand the structure of opinion among members of the group as a group and to provide a composite set of weights which can be discussed and adjusted in the course of debate.

This mathematical transformation is not always "clean-cut". Generally, sub-groups of individuals with similar responses become apparent as the composite ranking is determined. In this case, the sub-groups form an excellent basis for continued discussion by identifying the major and minor themes or differences around which to organize the discussion. However, occasionally

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*These techniques are described in a very readable manner in Chapter 2 of a Pelican Books paperback titled Mental Maps by Peter Gould and Rodney White.

Figure 3--Worksheet provided to group members to assist them in ranking factors used in assessing agricultural quality.

A

September 14, 1981

LAND USE CRITERIA WORKSHEET

A. AGRICULTURAL PRODUCTION

The following were selected at the August 18 meeting as preliminary criteria, or characteristics of land, which make it attractive to agricultural use.

Farmer attitudes and traditional commitment

Ground water availability

Soil quality which favors cultivation/productivity

Zoning which supports retention of agricultural use

Large, contiguous tracts of agricultural land

On the lower half of this page, please list these five criteria in order of their importance to you.
(Detach and return to Ray Pickering at the Planning Commission by September 23.)

A. AGRICULTURAL PRODUCTION

List the group's preliminary criteria in your preferred order of importance.

Most important	(1)__________
Second most important	(2)__________
etc.	(3)__________
	(4)__________
Least important	(5)__________

Please use this space and the reverse side of this detached portion of the page for comments and questions.

Your name:__________
This form will be returned to you at our next meeting.

September 14, 1981

A

individuals don't "fit" well into a group, or more general "chaos" may emerge in which most individuals' responses appear too unique to group together in any reasonable way. Such an outcome usually results from lack of agreement on factor definition or from different perspectives on the individual factors. A major benefit of the transformation technique is to expose lack of agreement on definitions at this early stage.

During the course of this work, an important distinction was discovered when the transformation technique was employed for the first attempt to rank factors for agriculture. Major differences were related to the participants' attitudes. These could be traced to vaguely worded instructions of the first worksheet which contradicted oral directions given during the meeting. One group's ranking reflected its participants' judgment of the actual order of influence of the factors on agricultural quality; this group attempted to describe what they perceived as actually happening in the county. The second group's ranking was based on a preferred order of influence; this group was concerned with prescribing a "better" order of influence. To remove this source of confusion, participants were asked to rank the factors again from both an "actual" and a "preferred" point of view. Familiarity with both points of view was required of each participant in order to make these assignments.

During a subsequent discussion, the group adjusted the weights estimated from the second attempt to rank the factors. The sum of all weights had previously been arbitrarily controlled to a 1000-point total. Note that these points can be interpreted in various ways and that 1000 points is simply chosen for convenience. The simplest interpretation of the weights shown in Figure 4 would be as proportional shares of total influence. The 225 points assigned to "farmer attitude" under actual influence would mean that among the factors chosen, this one has a 0.225 share (or almost one-fourth) of the total. Table 4 summarizes the weights developed for the factors designated for each land use.

Refine factor definitions: The purpose in refining factor definitions is to translate the concepts behind each factor, as it is defined for discussion, into actual data which can be used by the computer information retrieval programs. It is easy to take for granted the communication of ideas and concepts. However, only by clarifying precisely what is meant by the messages sent between thinking, reasoning beings can the factors be made understandable to the computer.

Although this task might have been accomplished early in the deliberations of a group more experienced in using computer-aided methods, it was withheld until factors were initially selected and their relative weights were assigned. Earlier introduction of these considerations could have encumbered the process or discouraged individuals who were contributing time from their busy schedules. Since the group had, by this point, a firm grasp of the concepts underlying each factor, refining definitions did not alter their understanding.

Figure 4--Adjusted weights for the actual and preferred influence of factors used in assessing agricultural quality. This figure is a reduction of a flip chart prepared during Task Force discussions.

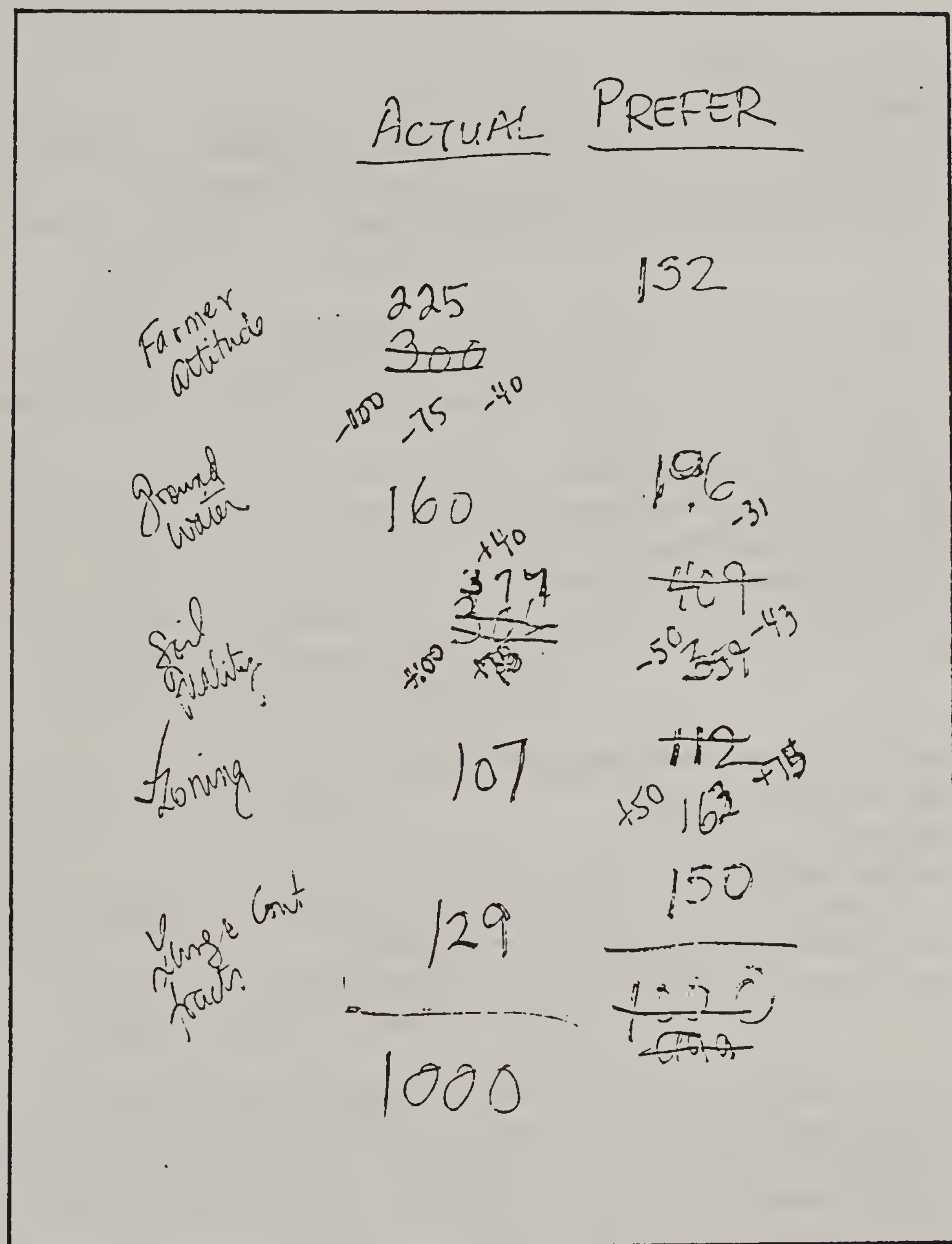

Table 4--Preliminary Factor Weights for Evaluating Land Use Quality Indices

FACTORS	WEIGHTS* Actual	Prefer
Agricultural		
• Farmer attitude and traditional commitment	225	132
• Groundwater availability	160	196
• Soil quality which favors cultivation/productivity	379	359
• Zoning which supports retention of agricultural uses	107	162
• Large contiguous tracts of agricultural land	129	150
Residential		
• Public sewer service	265	260
• Suitability for on-site disposal	129	111
• On-site groundwater availability	62	105
• Proximity for commercial centers	28	92
• Zoning for denser development	334	197
• Public water supply service	191	235
Commercial		
• Public sewer and water services (both)	146	242
• Minimal storm water problems	68	112
• Favorable zoning	144	253
• Visibility to the public	236	80
• Proximity to transportation routes	200	133
• Proximity to residential areas (population)	207	180
Industrial		
• Expansion around existing facilities	78	68
• Level land (minimal slope)	186	125
• Availability of power	150	132
• Public sewer and water services (both)	250	195
• Favorable zoning	100	272
• Access to heavy transportation	236	208

*Only results based on Actual weights are discussed in this paper.

Certain questions were presented to the group to insure their understanding and agreement on the way in which factors were defined for computer manipulation:

1) What source of data is readily available for defining the factor? If none is available, what should be used?

2) How should data which is not available be collected or estimated?

3) How should the data be classified or who can be consulted to classify the data?

4) How should numerical values be assigned to represent the degree to which data meets factor definitions?

This discussion produced a checklist which summarized the status of existing data, established preliminary definitions for computer use, and identified sources of assistance for developing needed data (Figure 5).

Some data, which had been "digitized" - or stored by electro-mechanical means on magnetic devices that are read by computers - were installed with the retrieval system. Other data had to be coded or translated into a computer readable form from maps and surveys. To manually code and keypunch data for each mapel was too time-consuming to be practical. Therefore, several time and labor saving techniques were used to construct computer readable data which captured the concepts discussed by the group:

1) translation of existing digitized data with the computer on a mapel-by-mapel basis

2) computation of new data from one or more map files with the retrieval system or user written programs

3) substitution of a simple file to approximate a more complex one so that manual entry of data becomes practical.

Each factor, by whatever means it was eventually described for computational purposes, was defined by a set of numerical values ranging from 0.00 to 1.00. For a given factor, one value of this range was assigned to each mapel so that the collection of all mapels for that factor represented its geographic distribution. A value of 1.00 was assigned to mapels where the factor was fully expressed and a value of 0.00 was assigned where it was absent. Intermediate values were assigned based on the degree of expression in each mapel.*

Of the digitized data which became available with the retrieval system, three major map files were translated to represent factors for the agricultural

*The reader will note that the values assigned to describe each factor's variation are on file with the Lancaster County Planning Commission. Maps of individual factor value distributions can be printed with the computer retrieval system.

Figure 5--Checklist created to summarize status of data needed to implement factors for assessing agricultural quality. This figure is a reduced copy of the form used during Task Force discussions.

AGRICULTURAL PRODUCTION

FEBRUARY 24, 1982

CRITERION	COMPUTER FILE	CONSULT	QUESTIONS/ INTERPRETATIONS
✓1. FARMER ATTITUDES & TRADITIONAL COMMITMENT	no	Township supervisors	initiate to reach each supervisor to get his judgment - letter to be drafted by LCPC, Garth Becker(?) others(?)
✓2. GROUND WATER AVAILABILITY	no will be digitized	LCPC (planning commission)	geology map — but use historical average of wells in each category need threshold. or scale to apply wts. probability(?)
3. SOIL QUALITY WHICH FAVORS CULTIVATION/PRODUCTIVITY	yes	SCS	which soils - Contact Frank Lucas with SCS
✓4. ZONING WHICH SUPPORTS RETENTION OF AGRICULTURAL USE	? clean up edit digitize file	LCPC	see the "Reporter" article on Ag Zoning. (May 1981) how to create map or use zoning map.
5. LARGE, CONTIGUOUS TRACTS OF AGRICULTURAL LAND Circle? approximate 7×7 9×9 variable?	ok?	Sayers	"use" well-surrounded" concept with computer algorithm don't downgrade forest land as much as urban uses.

evaluation. These were the subsurface geology, soil mapping unit, and composite township zoning files.

Consider, for example, how this was done for the soil mapping unit file. The "name" (in numerical form) of a single soil mapping unit was stored in each mapel. Associated with this name were a variety of interpretations, among which was an expected production of corn in bushels per acre. Using the soil type which is expected to produce the most bushels per acre as the standard, each remaining soil type was rated as a proportion of this maximum. These "proportion-of-the-maximum" values were then substituted for soil names by the computer to create a new map file in the database. This map file then represented the "soil productivity" factor in this evaluation. The following are a few examples of this translation:

Soil Series	Mapping unit symbol	"Name" stored in computer	Corn yield (bu/acre)	Proportion of maximum (max = 135)	Factor values used*
Comus	Cm	25	135	1.00	1.00
Conestoga	CnA	26	135	1.00	1.00
Conestoga	CnB	27	135	1.00	0.60
Conestoga	CnC	28	120	0.88	0.35
Duffield	DbA	29	135	1.00	1.00
Duffield	DbB	30	130	0.96	0.57
Elk	EcA	32	135	1.00	1.00
Elk	EcB	33	130	0.96	0.57
Elk	EcC	34	120	0.88	0.35

*Actual soil values, which attempted to incorporate the concept of "sustainable production" for each soil, were eventually borrowed from the land evaluation portion of the Lancaster County LESA effort designed by the Soil Conservation Service. These values do not include adjustments for conservation practices.

Similar translations were made for groundwater and zoning. Finding an objective and realistic basis upon which to distinguish important variations for some factors continues to be a major weakness in this method. The principal means employed in overcoming this problem has been to explicitly state what values are used in computing the final index and to allow these values to be amended as a result of group discussion and debate. The zoning factor, in particular, presented this sort of problem. Values assigned to zoning categories represented "good judgment" of the relative effectiveness of the specific ordinances in providing security for farmland. "Good judgment", in this case, was expressed explicitly (i.e., numerical share of the best existing condition) even though it was not measured objectively.

To estimate the "contiguousness" or "well-surroundedness" of agricultural areas, a computational technique was developed. This technique also relied on previously digitized data, the land cover map file, but did more than simply translate the file on a mapel-by-mapel basis. In this case, a computer program was written to examine each ten-acre mapel. If the mapel was coded as an agricultural cover type, it was treated as the center of a small region roughly circular in shape and about 600 acres in size. This region was examined to estimate the disruption caused by non-agricultural uses

(primarily urban uses) and the "concentratedness" of the agriculture in the region around the central mapel. Using a counting procedure modified by these "disruption" and "concentration" guidelines, a score was computed for the region and assigned to the central mapel. As every agricultural mapel was in turn examined for its regional context, a score was computed for each. The maximum possible score for a completely agricultural region was used to scale these scores on a relative basis (i.e., from 0.00 to 1.00, with 0.00 being assigned to all non-agricultural mapels and 1.00 being assigned to any agricultural mapel completely surrounded by other agricultural mapels in the 600 acre mini-region).

The final factor of the agricultural assessment, "farmer attitude", represents an influence which was felt to be extremely important but very difficult to specify - especially to specify as precisely as is required for computer manipulation. Clearly, there was no hope of evaluating each 10-acre mapel of the agricultural land cover data for its owner's attitude in any practical or objective manner. A simple surrogate, or approximate substitute, was developed. By rating whole townships, data entry problems were simplified tremendously, and this factor was prepared by a simple translation of an existing township map file already stored in the retrieval system.

However, the question of what translation should be made for each township was not simple. Township supervisors were polled with an informal survey, which attempted to assess each township's "farmer attitude" from at least five major points of view:

1) commitment to farming as a future livelihood

2) support for farm preservation programs

3) use of soil conservation practices

4) stabilizing effects of traditional life styles

5) investment in farm improvements.

These points may contradict, especially if given equal weight: traditional farmers may not invest as much in buildings or equipment or be as committed to soil conservation measures or farm preservation programs; yet they are clearly committed to farming. However, the estimates developed in this exercise appeared to form patterns that the committee felt were reasonable for Lancaster County. Again, as in previous cases where subjective judgment was employed, an explicit statement of the values used was offered in place of more objective measurements.

Calculate index values and display distributions: The purpose of this step is to determine the consequence of previous decisions by actually calculating the index value for each mapel and then to examine the distribution of index values over all mapels. The outcome of prior decisions becomes clearer in this step. It is with these decisions that one may disagree. What is accomplished in this step of the procedure is merely a mechanical consequence of those earlier choices and decisions.

This method has been designed to employ a computer, for although the calculations are simple on the one hand, they are numerous on the other. The sheer number of calculations require this assistance. In addition, the evaluation is much more easily adjusted and repeated if data handling tasks and computations are automated.*

The typical calculation** may be summarized as follows:

$$A = \sum_{i=1}^{5} w_i F_i$$

where A = index of agricultural quality for one ten-acre mapel,

w_i = weight assigned to the i^{th} factor,

F_i = value of the i^{th} factor for agriculture.

This is a concise way to express simple arithmetic. The important expression in this equation is the product, $w_i F_i$, which is the weight of a factor times the value of that factor. For example, from the previous discussion, the "soil productivity" factor has a weight of 379 points (of a possible 1000 points). If the factor has a value of 0.35 for a particular mapel (the soil might be EcC or CnC illustrated earlier) then the product of these two (379 x 0.35 = 133) determines the contribution of soil productivity to the agricultural index (A) for that specific 10-acre mapel. Each factor, such as soil productivity, may vary from mapel to mapel and therefore its contribution to the index value computed for each mapel may vary.

The summation symbol ($\sum$) specifies that the five individually weighted factor values should be added together for a given mapel. By assuming values

*The use of variable weights for individual factors is impossible if manual techniques based on map overlays are contemplated.

**The calculation which is used to derive index values ignores redundancy, interactions, or synergistic effects which might be incorporated by more complex functions that could account for the coincidence of particular factors. However, despite these possible shortcomings, the function used is simple to understand and does give a good first approximation.

for each factor in the case of a hypothetical mapel, this computation can be demonstrated as follows:

$$
\begin{aligned}
\text{for}\quad i=1:&\quad w_1F_1 = 225 \times 0.80 = 180\\
i=2:&\quad w_2F_2 = 160 \times 1.00 = 160\\
i=3:&\quad w_3F_3 = 379 \times 0.35 = 133\\
i=4:&\quad w_4F_4 = 107 \times 0.75 = 80\\
i=5:&\quad \underline{w_5F_5} = 129 \times 0.66 = \underline{85}\\
A = \sum_{i=1}^{5} w_iF_i &\quad = 638
\end{aligned}
$$

The same calculation is performed, in turn, for every other mapel. Not only is the burden of these numerous calculations accomplished with relative ease by the computer, but the result in each case can be stored and referenced to the location (the specific mapel) for which it was computed*.

Note that in the example cited above, the index value of 638 concisely summarizes the <u>relative quality</u> of the mapel evaluated. Similarly, this calculation is performed for each relevant mapel. The index value is relative since it is measured on an arbitrary scale which ranges from 0 to 1000; any single value takes on significance (that is, whether it is "high" or "low") only when compared with the scores for all other mapels. Consider also that this index score (638, in this particular case) may be identical to that for another mapel which possesses different values for some factors. For example, if only the first two factors (0.80 and 1.00 respectively, for factors 1 and 2 in the example above are comparable to 1.00 and 0.72 below) have slightly different values.

$$
\begin{aligned}
w_1F_1 &= 225 \times 1.00 = 225\\
w_2F_2 &= 160 \times 0.72 = 115\\
w_3F_3 &= 379 \times 0.35 = 133\\
w_4F_4 &= 107 \times 0.75 = 80\\
\underline{w_5F_5} &= 129 \times 0.66 = \underline{85}\\
A = \sum_{i=1}^{5} w_iF_i &= 638
\end{aligned}
$$

---

*The value stored for a specific mapel may be referenced by subscripts for its row (r) and column (c) positions (A_{rc}) in the grid matrix.

Mapels, as "seen" through their index values, may no longer be unique because of the particular combinations of factors they possess. Their agricultural quality index values are their total, transformed expression and the common basis for measuring their quality. This results, not from the computation itself, but from the reasoning described earlier in this report.

Once computed and stored, the index values may be summarized in several ways. In particular, their distributions - both statistical and geographical - are concise ways for understanding and evaluating how well the earlier deliberations of the group have been captured by the reason and mechanism of this process.

Statistic		Index Value
Range	minimum	172
	maximum	981
Mean		811
Standard deviation		± 107
Median		823
Mode		831

Although this statistical summary gives the impression that index scores were "reasonably" distributed and therefore might give a good indication of agricultural quality in Lancaster County, the geographical distribution is less encouraging (Figure 6). Concentrations of higher index scores appearing in this figure suggest that data entered on a township basis (surrogate simplification) have produced unrealistic distortions. One would not expect agricultural quality to be so sharply delineated or abruptly terminated by municipal political boundaries.

Note that computer printed maps are hereafter used as the principal means for illustrating index evaluation results. Other index summaries do not reveal as concisely or pointedly the geographic implications of the factors or their relative weights. Other summaries are however, useful and are initially needed to make decisions about classifying index values for computer mapping programs.

Review index distributions for needed adjustments: The purpose of this step is to bring the preliminary result into greater agreement with the expectation or image which guided participants in selecting factors and in giving each of these factors relative weights. The preliminary result illustrated in Figure 6 is the basis for making this adjustment. It also cautions the reader to examine each susequent result carefully.

Based on Task Force suggestions, modifications were made in the assignment of factor values for "farmer attitude" and for "contiguousness". In the preliminary version, values for "farmer attitude" had been assigned to groups of townships, each township in a particular group receiving the same value. To revise this, values were assigned to individual townships so that their

Figure 6--Preliminary geographic distribution of the agricultural quality index. Darker symbols represent higher index scores. Interior vacancies (white) are the non-agricultural portion of Lancaster County: included are urban places, scattered development, forest, and water.

distribution about their group average was incorporated. This permitted overlapping in the value ranges of the groups' member townships - in effect creating a more mixed patchwork of townships which was felt to follow the poll of township supervisors more closely than previously.

The computation of "contiguousness" was revised to elevate values for agricultural areas adjacent to woodland. The Task Force reasoned that woodland does not disrupt the contiguousness of farming areas. Therefore, the contribution of woodland to this computation was increased to 80% (as compared to 50% used previously) of the amount attributed to similarly situated open farmland (pasture or cropland). This change, all other things being equal*, was expected to elevate index values in the southern part of the county.

Subsequently, it was suggested to the Task Force that the inclusion of "zoning which supports retention" be dropped from the agriculture evaluation. The strong influence of zoning on the preliminary evaluation was noted earlier to create artifically abrupt changes. Stronger agricultural zoning continues to be a popular and growing trend in the county. By including it, the evaluation result could quickly become outdated and would otherwise tend to obscure the underlying agricultural quality defined by other factors. By excluding zoning, the Task Force should get a clearer sense of where agriculture zoning may be needed by comparing results with current zoning maps.

To remove zoning from the evaluation, the weight for this factor was proportionally redistributed to the remaining factors with the following result:

	Actual Weight	
Factor	Previous	Adjusted
Farmer attitude and traditional commitment	225	252
Groundwater availability	160	179
Soil quality which favors cultivation/productivity	379	424
Zoning which supports retention of agricultural uses	107	0
Large contiguous tracts of agricultural land	129	145

Note that by proportionally redistributing the weight for zoning to the remaining factors, their relative influence on the result is unchanged and the point total is still 1000.

The reliability of existing data which approximate "groundwater availability" was also discussed with the Task Force. It was noted that these data fail to distinguish important local variations and problem areas. Recognizing its potential shortcomings, the Task Force choose to retain this as the best approximation available.

*When changing several factors simultaneously, it is not possible to easily predict the impact of any single component on the final outcome.

Recalculate and display revised index values: The purpose of this step is to implement the adjustments considered in the previous one. The calculation procedure is not altered; only factor values or factor weights are adjusted as discussed above.

The geographic distribution of index scores for the adjustments described above does seem more realistic (Figure 7). For this revised agricultural evaluation the classification of index scores places the following acreage in each category shown on the map:

Category	Approximate Acreage	Range of Index Scores
Fair	151,000	0 - 699
Good	223,000	700 - 819
Better	24,000	820 - 939
Best	26,500	940 - 1000

Note that with only about 25,000 acres in each of the two categories with the highest scores, definite clusters of darker print symbols have formed in several places on the map: one lies northeast of Lancaster City and is centered around the development corridor which passes through New Holland; another lies northwest of Lancaster City and is ringed by Lititz, Manheim, Mount Joy and East Petersburg Boroughs.

To test whether these particular clusters are the nuclei of qualitatively better agricultural regions, the boundary between classes of index scores can be shifted to allow more "good" land into the "better" and "best" categories. This shift is illustrated in Figure 8A, a histogram which shows the distribution of acres of agricultural land over the range of index scores. Note that this figure shows the classification boundaries for Figure 7 and the reclassification made to explore the growth of the two clusters mentioned above. An additional computer map is included to illustrate such a change (Figure 8B). This map has been prepared from the same index distribution shown in Figure 7. Although prepared at a somewhat larger scale, this map differs principally in the way category boundaries are positioned.

The classification used of Figure 8B produces the following acreage in each category shown on the map:

Category	Approximate Acreage	Range of Index Scores
Fair	47,000	0 - 569
Good	92,500	570 - 689
Better	240,000	690 - 829
Best	45,000	830 - 1000

This reclassification, displayed in Figure 8B, shows that the area northwest of Lancaster City does form a distinct nucleus of qualitatively superior land for agriculture in Lancaster County.

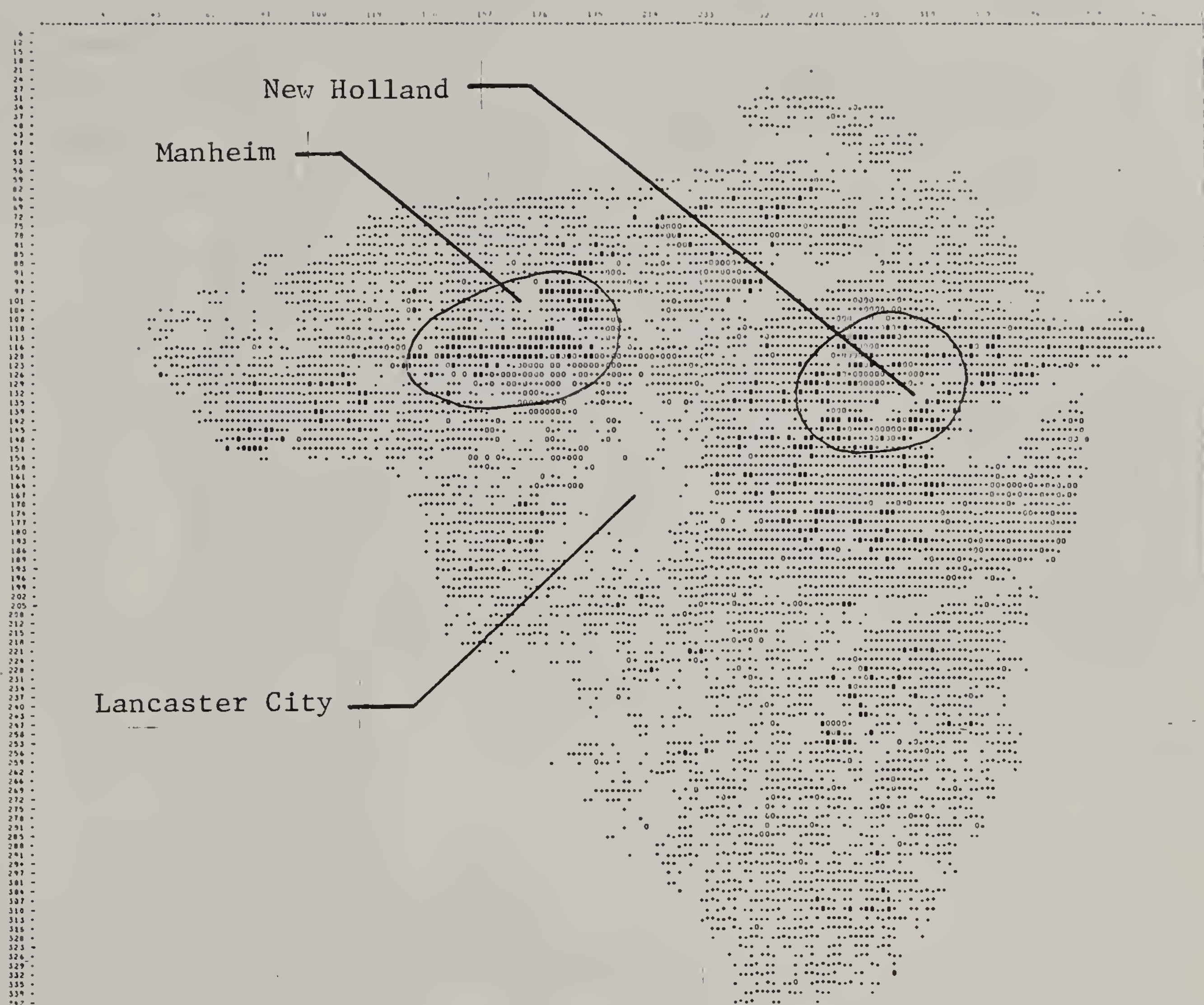

Figure 7--Revised geographic distribution of index values for the agricultural quality evaluation. Circled areas appear to be regional clusters of higher quality (see text).

Legend

.. FAIR
++ GOOD
00 BETTER
■■ BEST

Scale 1:555,000
Lancaster County
Pennsylvania

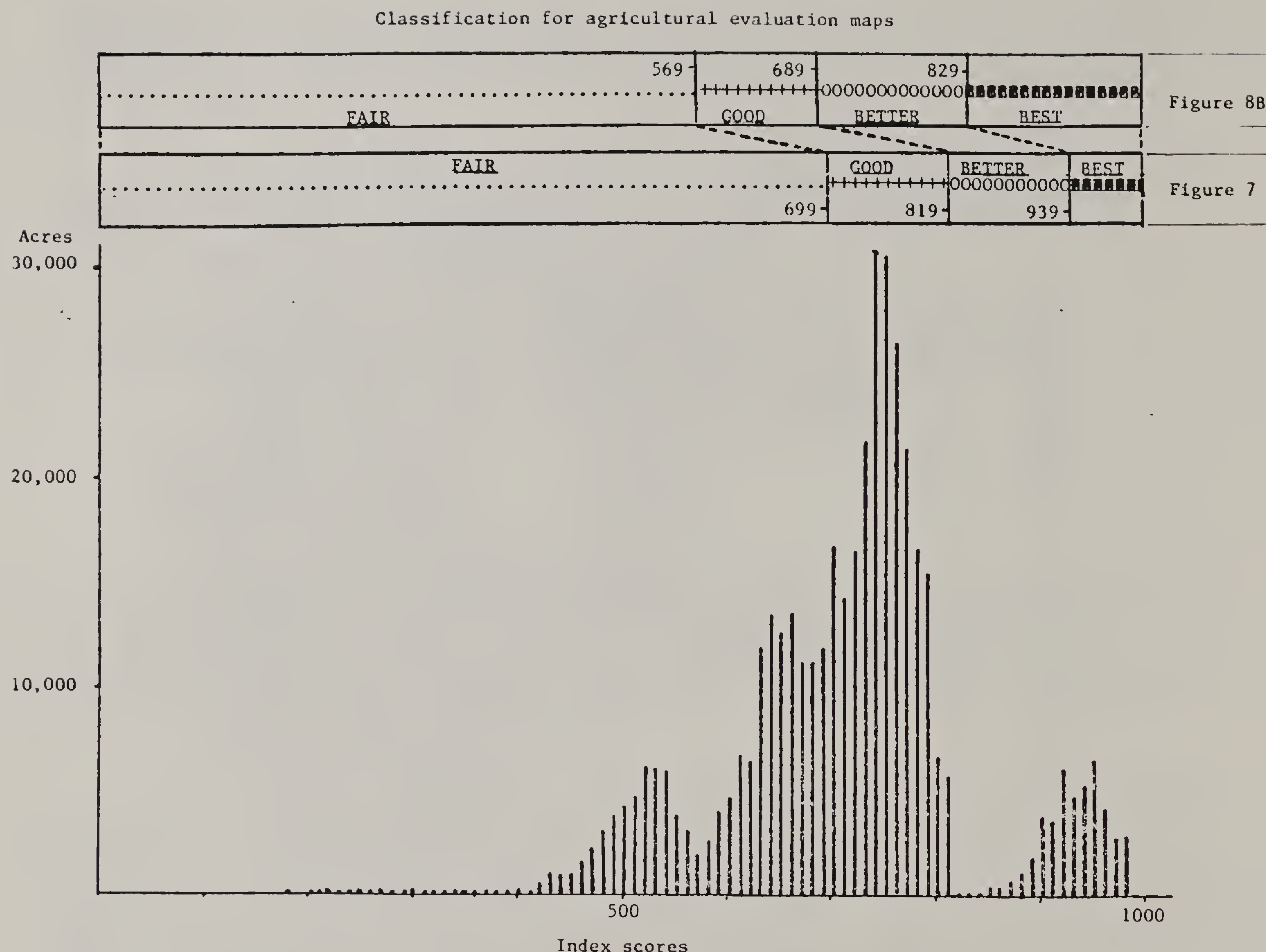

Figure 8A--Histogram showing the distribution of acres of agricultural land over the range of index scores. The classifications of these scores for the agricultural evaluation maps displayed in Figure 7 and 8B are diagramed at the top of this figure.

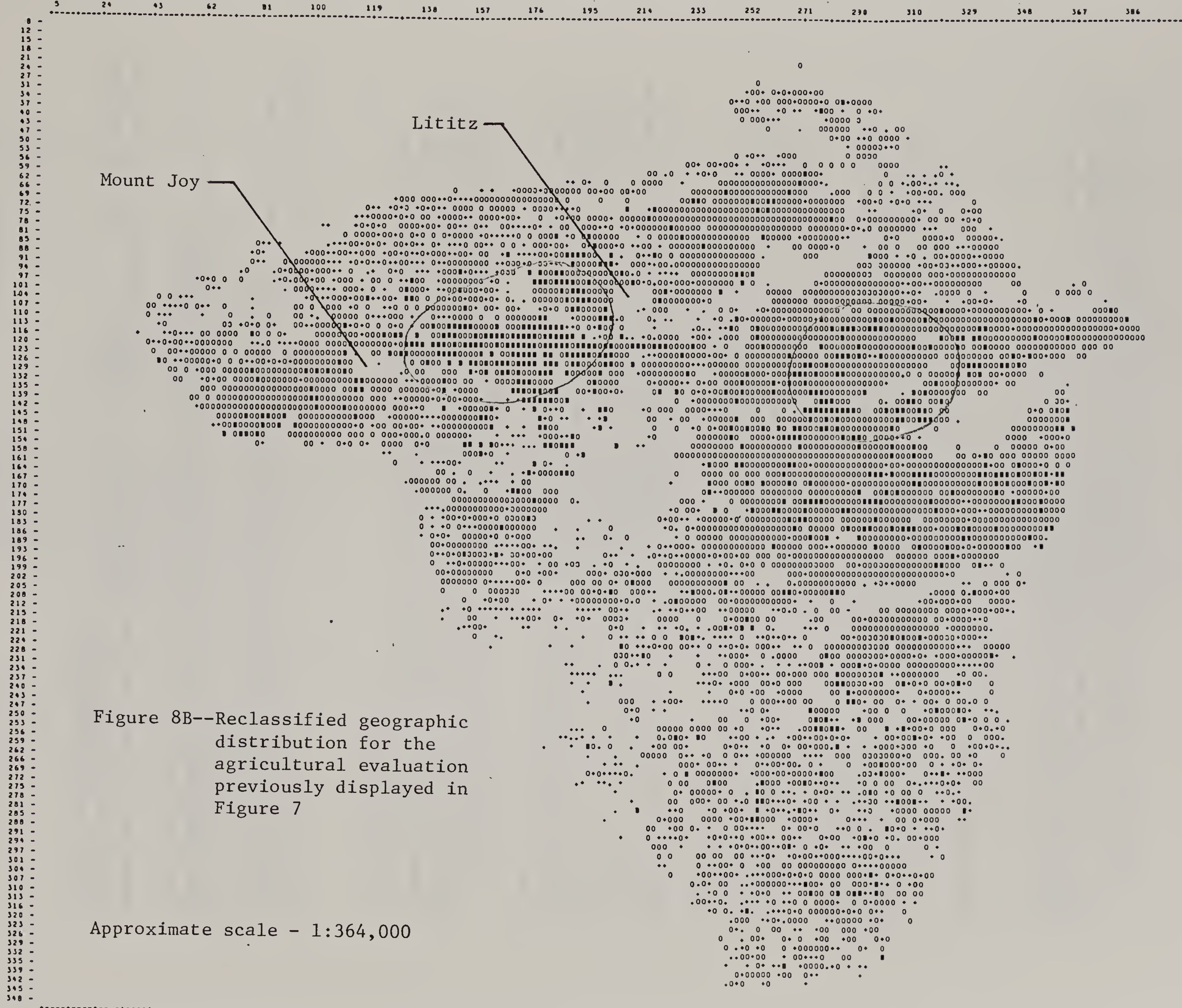

Figure 8B--Reclassified geographic distribution for the agricultural evaluation previously displayed in Figure 7

Approximate scale - 1:364,000

This result, as well as the initial result obtained for other land uses Figure 9)* are the basis for all subsequent discussions in this paper. Other land use evaluations have not been adjusted since initial results appear to be reasonable. However, this should not preclude closer inspection and possible adjustments beyond the scope of this report.

Predict Future Land Use Patterns

Future land use patterns are developed by combining the potential pattern for individual land uses according to certain rules. These rules are based on assumptions described briefly in the INTRODUCTION to this report. The amount of land needed to satisfy anticipated growth has also been determined elsewhere.**

In this task, there are at least two advantages in using a computer. Different amounts of land use change can be tested and the rules for merging land uses can be revised, making alternative ideas easier to test. The ease with which the resulting data can be stored and subsequently manipulated or examined is also a distinct advantage.

Rules for merging uses: The purpose of this step is to establish a logical procedure for predicting land use change. The rules of this procedure define a sequence of actions for assigning land uses into a future pattern over the same area for which separate land use indices have been developed (Table 5). These demonstration rules are intended to be consistent with the assumptions outlined in the INTRODUCTION. They are a beginning and can, without doubt, be made more realistic. The cost of realism is greater complexity.

The most obvious departure from reality exhibited by this particular set of rules is due to the fact that a particular urban use may or may not "choose" the best available parcel. Even if a land developer has knowledge of what is the best (as it has been determined by this evaluation) land prices may dictate his choosing other land just because it is available at a better price.***

---

*Maps of all final land use evaluations and subsequent predictions are included in Exhibit B at a larger scale so that the reader may remove them from the text for side-by-side comparison.

**The demonstration described here follows the acreage allocation for the "Predicted Future" described in Chapter II of the Main Report.

***Notice that this statement implies that each quality index mirrors the geographic distribution of land prices for that particular use. This is obviously a rather ambitious assumption.

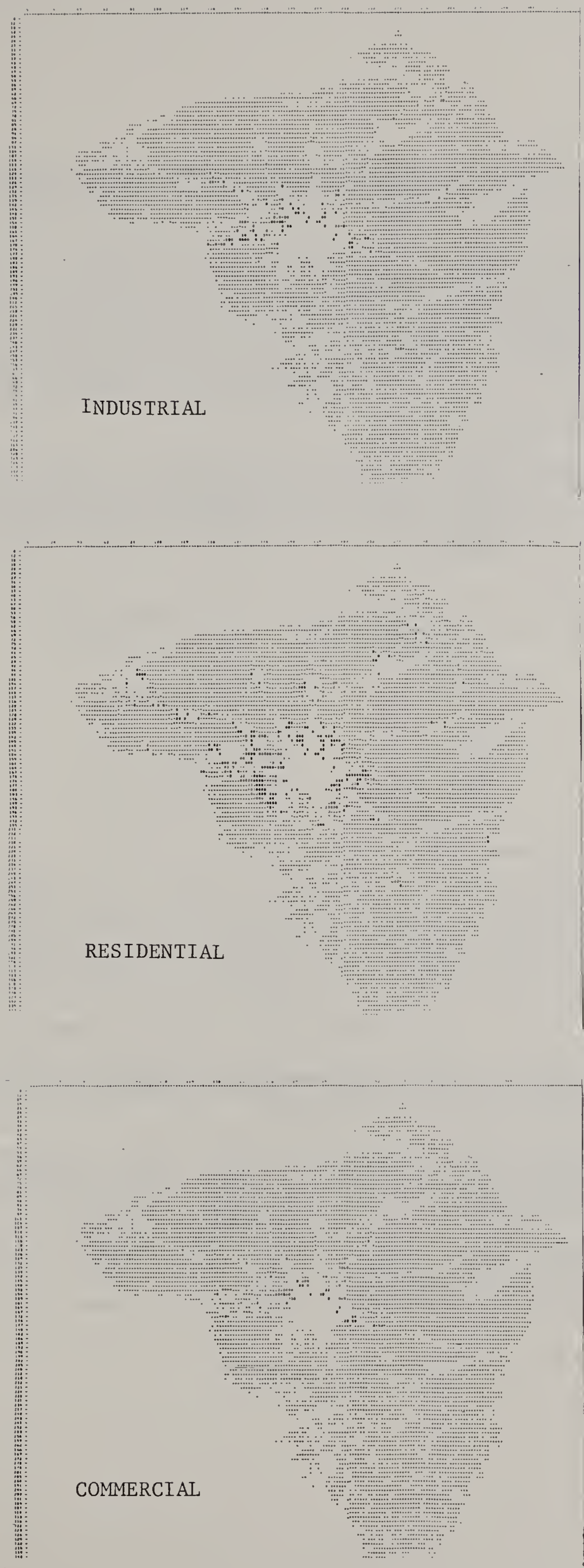

Figure 9--
Geographic distribution of evaluation scores for urban land uses

Legend

.. FAIR
++ GOOD
OO BETTER
■■ BEST

Scale 1:854,000
Lancaster County
Pennsylvania

Table 5: Procedure for Merging Land Uses for the Demonstration of Future Land Use Patterns*

Rule 1: Higher index scores for any given land use are equivalent to higher potential for development (or continued use in the case of agriculture). For example, a mapel with a higher score for residential use will be "developed" (remember, this happens only in the computer) before a mapel with a lower score for residential use. The purpose for creating the four separate land use indices was to be able to make exactly this decision.

Rule 2: Since only agricultural land has been evaluated for each of the four possible uses, the first step is to automatically assign all land to agriculture (in the computer). This becomes the future land base on which other uses are added.

Rule 3: The remaining three uses are prioritized according to their "ability to pay" more per acre for land. This order is:

Priority	Land Use
First	Industrial
Second	Commercial
Third	Residential

Rule 4: The allocation of urban land is first completed for the first priority use. On the future land base, industrial mapels are "created" until the acres required to meet future industrial development needs are completely satisfied. These are created according to the procedure described in Rule 1. If a mapel is assigned to industrial use it may not be selected for either remaining use.

Rule 5: The allocation of land for commercial use is then made until acreage requirements are met. Mapels are selected according to Rule 1, with the exception that those assigned to the industrial use are by-passed, regardless of the commercial index score.

Rule 6: Residential mapels are then allocated to the future land base. Both previously assigned industrial and commercial mapels are bypassed in order to satisfy the acreage quota for residential land.

Rule 7: All mapels in the future land base not assigned to one of the three urban uses become future agricultural land.

*Rules should be performed in the sequence indicated.

Merge land uses to form a future pattern: The purpose of this step is to execute the procedure defined in Table 5. The consequence of assigning land uses in "priority" or "land use" steps may not be completely evident in this set of rules. In executing these assignments, suitable sites for the second or third priority uses may be taken by a higher priority use. In order to "find" enough land, the computer program, which made these assignments, was executed several times. During each round, or iteration, an incremental change in the "acceptance threshold" of each land use index was made. With each change, more land becomes available to the land use(s) needing it to meet the pre-specified target amount.

In the way in which this step was implemented, the assignment may "over" or "under" allocate a particular land use. This results both from the "lumpy" nature of index value distributions (i.e., multiple mapels at each index value) and from the relative simplicity of the allocation program. The acreages targeted and actually allocated are shown below:

Land Use Category	Target Allocation	Actual Allocation
Industrial	3,456	3,499
Commercial	2,304	2,154
Residential	18,240	19,086
Total	24,000	24,739

The target allocation is based on acreages shown for the Predicted Future of Table II.6 in Chapter II of the Main Report. Residential use includes land cover area attributed to residential, institutional, and public parks. The commercial and industrial categories have been increased in proportion to their areas so as to include utilities.

Display map of future land use pattern: The geographic distribution of this additional 24,739 acres of urban land can be displayed so that allocations to particular uses are evident (Figure 10). Careful inspection of this figure will reveal that, although the predominant share of new development occurs around Lancaster City, some development has been distributed in many of the outlying communities. The actual amount of development depicted in this figure (i.e., number of symbols printed) is relative to the scale of the map (which was originally 1:150,000 before being reduced to the size shown in Figure 10). Although some spots of development may not appear at this scale, the relative share of each type of development is not altered by the map scale.

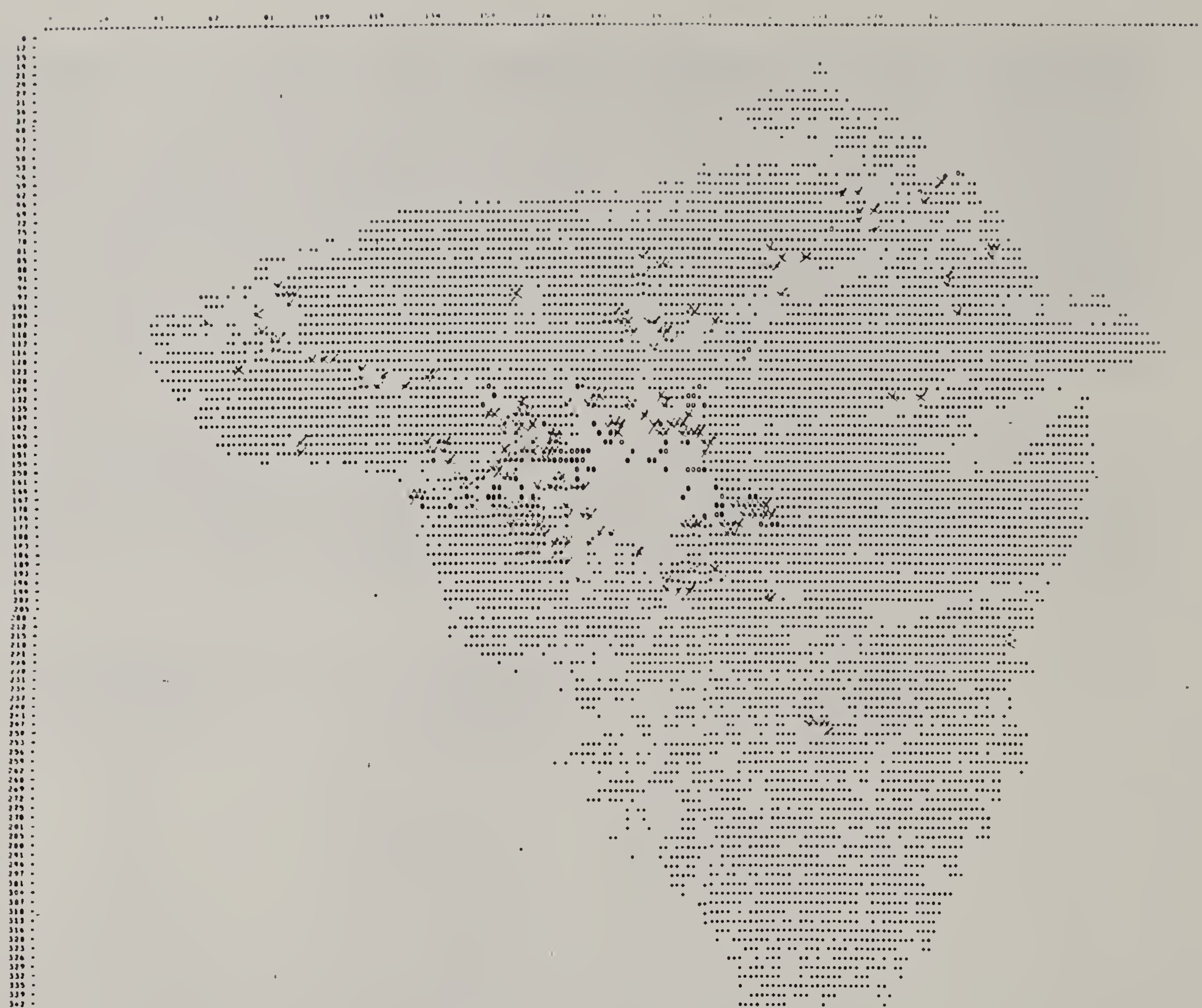

Figure 10 -- Possible geographic distribution of future land uses

Legend

••	LAND REMAINING IN AGRICULTURE
XX	CONVERTED TO RESIDENTIAL USE
00	CONVERTED TO COMMERCIAL USE
■■	CONVERTED TO INDUSTRIAL USE

Scale 1:555,000
Lancaster County
Pennsylvania

Estimate Conflict with Agricultural Use

Conflict over the use of agricultural land can be defined in various ways. The purpose of this phase of the method is to estimate conflict in a specific way. Both the amount (acres) and the location of the conflict areas are estimated. In the previous section of this report, one distribution of future land use (i.e., the possible pattern of urban development on existing agricultural areas) was prepared and exhibited. In this section, potential conflict, which may arise because of this hypothetical projection of new development, is examined.

If the objective of maintaining the vitality of Lancaster County agriculture can be achieved by preserving the agricultural land in the county, then "conflict" occurs where urban uses are most likely to compete for this land. In this sense, conflict can arise in isolated localities of the agricultural area. The use of isolated portions of this agricultural land for residential, commercial, or industrial purposes would be interpreted as weakening or diminishing the overall capability and vitality of agriculture as an industry. It is in this sense that conflict is estimated by the method developed here.

Preserving even the best agricultural land, however, does not insure that this land will occur in large contiguous areas which can be farmed efficiently or which minimize nuisances between agriculture and surrounding urban areas. Neither does preservation insure that the consequent arrangement of urban development will be particularly "desirable" in the way in which this arrangement relies on existing urban services or in which it requires extension of these services. The aspects of prudent land use go beyond a place-to-place interpretation of conflict. The interaction and mingling of land uses raise complex issues which should also be examined in a broader, comprehensive context. The reader is cautioned that the method presented here does not evaluate this overall context, but builds its result through a mapel-by-mapel evaluation. However, that result does provide a view of the county which will contribute to a more comprehensive perspective.

Define aspects of conflict examined: The purpose of this step is to define an operational sense in which conflict is examined. This definition is then applied to evaluate the previously predicted loss of agricultural land.

Two aspects of this method are developed here in order to examine the intensity of conflict. The first aspect determines where conflict is likely to exist among two, three, or all four land uses. By partitioning the total potential area into two qualitatively distinct groups ("best and "not-best") for each land use*, a second aspect is developed which examines the degree of conflict between any given pair of land uses.

*Only two groups of land quality for each land use (i.e., best and not-best) have been used for simplicity. More groups are possible in order to make even finer distinctions in conflict definition when this is appropriate.

These two aspects of conflict can be illustrated in a Venn diagram, a schematic way of representing these concepts (Figure 11, page 38). The largest circle in the diagram represents all agricultural land; the four remaining smaller "circles" (or ovals) represent some portion of this area which is "best" for each of the four land uses. Conflict is categorized by the "sectors" resulting from these overlapping circles. Note that the areas shown in Figure 11 are not in proportion to actual acreages; the figure is only a conceptual diagram.

The first aspect of conflict is defined in Figure 11 by the number of best-land circles which overlap. The sector labeled "16" comes into conflict for the best of four uses, whereas the sector labeled "4" is in conflict for the best agricultural and residential uses only. The sector labeled "3" is considered to conflict even less severely since this best-land for residential purposes does not overlap with any of the other circles of best-land.

The second aspect of conflict is only partially illustrated by Figure 11. This aspect depends on the size of the circles representing the best land for each use. At one extreme, all of the circles could grow to the size of the largest circle, which represents all agricultural land; in this case, all other uses would automatically be in a severe state of conflict with all agricultural land. At the other extreme, the size of each best-land circle could conceivably shrink enough that no overlapping occurs; this would be interpreted as evidence of harmony in the way land uses are allocated since no severe conflicts would exist. A more reasonable and instructive approach is to establish realistic amounts for each of the three urban uses, as defined for the future land use pattern predicted above, and to designate an arbitrary amount of agricultural land as best.* In this latter case, some intermediate amount of overlapping will probably occur.

Make decisions to determine type and location of conflict: The purpose of this step is to specify how many acres of land will be considered best-land for each land use category and to determine where these acres are located for each use. Specifying the amount of best-land for each use is based on the previous attempt to allocate a future land use pattern. Determining the location of these areas relies on the quality index for each land use.

The amounts of land assigned to the best-land category and the index scores (threshold) required to obtain these amounts for each land use are as follows:

Land Use	Best-land	
Category	Acres	Threshold
Industrial	3,499	739
Commercial	4,814	729
Residential	20,381	759
Agricultural	273,757	699

*The amount of best-land for agricultural use could be increased gradually to study the change and growth in conflict locations.

The amounts shown for the three urban categories correspond to the amounts actually allocated in preparing the future land use patterns (see page 33). Note that the acreage listed above for the commercial and residential uses are larger than the amount actually allocated in that future pattern. These differences are due to the fact that many commercial acres (4,814-2,154 = 2,660 acres) coincide with industrial acres (which had priority), and that some residential acres (20,381-19,086 = 1,295 acres) coincide with either commercial or industrial acres (which had priority). These differences can be accounted for in the definition of conflict as it is illustrated in Figure 11: the differences actually estimate the area of overlap for the commercial and industrial circles (sectors 13, 14, 15, and 16 in Figure 11) and for residential, commercial, and industrial circles (sectors 7, 8, 11, 12, 15, and 16 in Figure 11), respectively.

Since the amount of land associated with each index value is known for each land use, a threshold index value or score can be associated with the acreage needed to meet the best land requirement. Mapels of the appropriate index with values greater than this threshold score will be included in the best-land category for that land use (see page 36).

After the threshold scores are identified, each mapel is assigned to one of the specific conflict categories shown in Figure 11. This assignment is based on a decision process which produces one of 17 numbers (0 to 16) for each mapel (Figure 12). These numbers are only a convenient way to name the sectors created by the overlapping circles of Figure 11 and to relate them to a specific "branching path" of the decision tree in Figure 12. As names, the numbers 0 through 16 in these figures have no relative rank or value; they simply identify or name the conflict categories.

Figure 12 illustrates how the conflict sector "name" is derived for each mapel assigned to a conflict map file by examining the corresponding mapels from each land use evaluation map file. Beginning on the left, a mapel "moves" through the branches of the diagram. At each branch a decision is made concerning a land use evaluation result for that mapel. (Note that the abbreviated name of each land use is immediately to the left of each decision branch.) The values show in parentheses are accumulated during this "passage" producing a unique sector "name" for each of the 17 possible "paths". For example, the "path" of agricultural land that is "best-land" for all land uses produces a name of "16" (i.e., 1+1+2+4+8=16) and the "path" of agricultural land that is "not best-land" for all land uses produces a name of "1" (i.e., 1+0+0+0+0=1). Note that "0" (zero) is reserved for non-agricultural land that was not evaluated. The threshold index values used to distinguish "best-land" (B) from "not best-land" (B̸) are listed on page 36.

<u>Display distribution of estimated conflict among uses</u>: The purpose of this step is to show the outcome of the decision process for assigning each mapel to one of the seventeen conflict categories. The accumulated result of this process is an estimate of the area associated with each sector of the diagram in Figure 11 and a map which attempts to display the intensity of conflict.

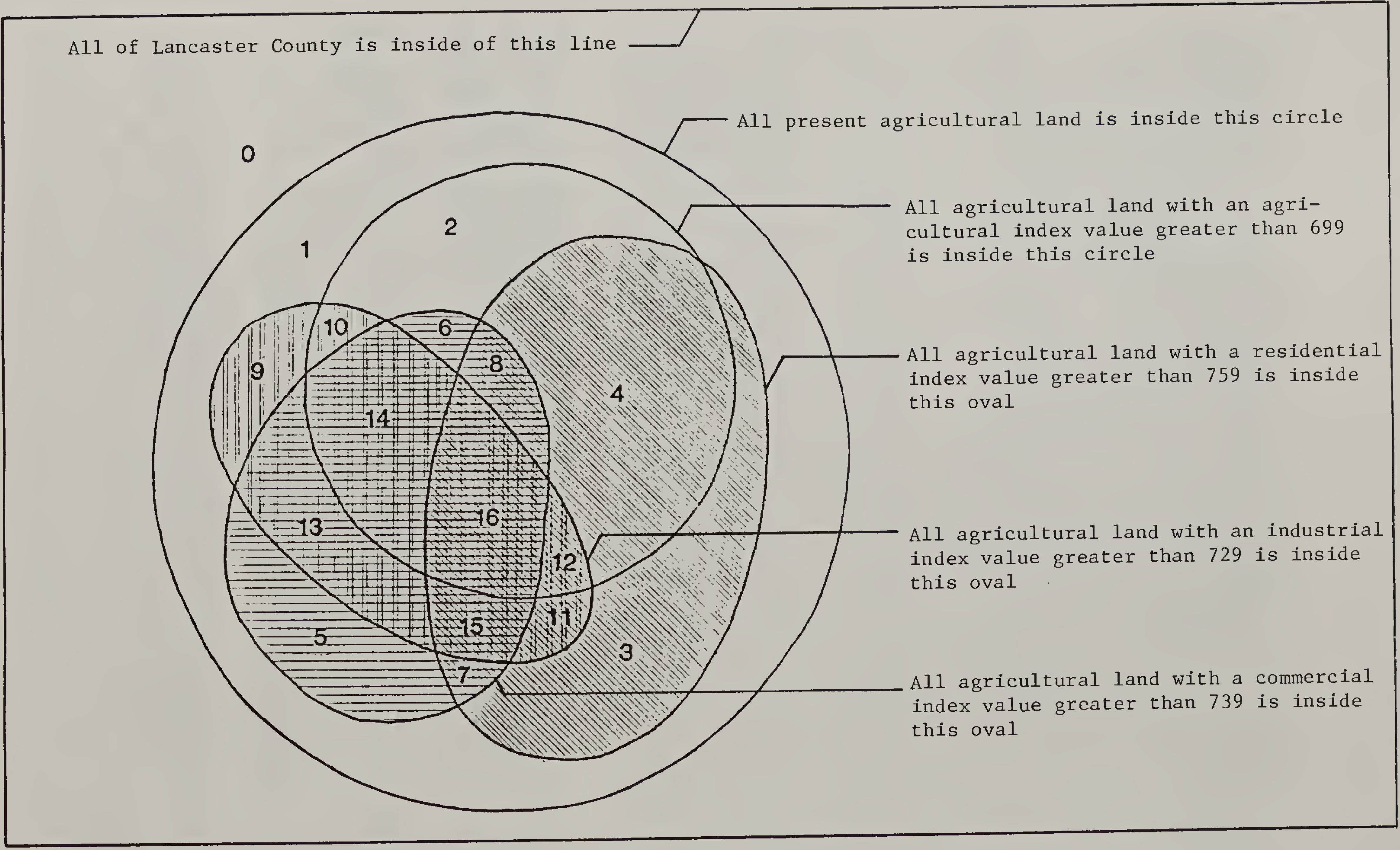

Figure 11--Venn diagram illustrating the 16 conflict categories for the area which was agricultural land in 1978. Note that the "circles" are not drawn in proportion to the area of land they represent. Each number identifies (or names) a sector of the diagram formed by the intersecting circles.

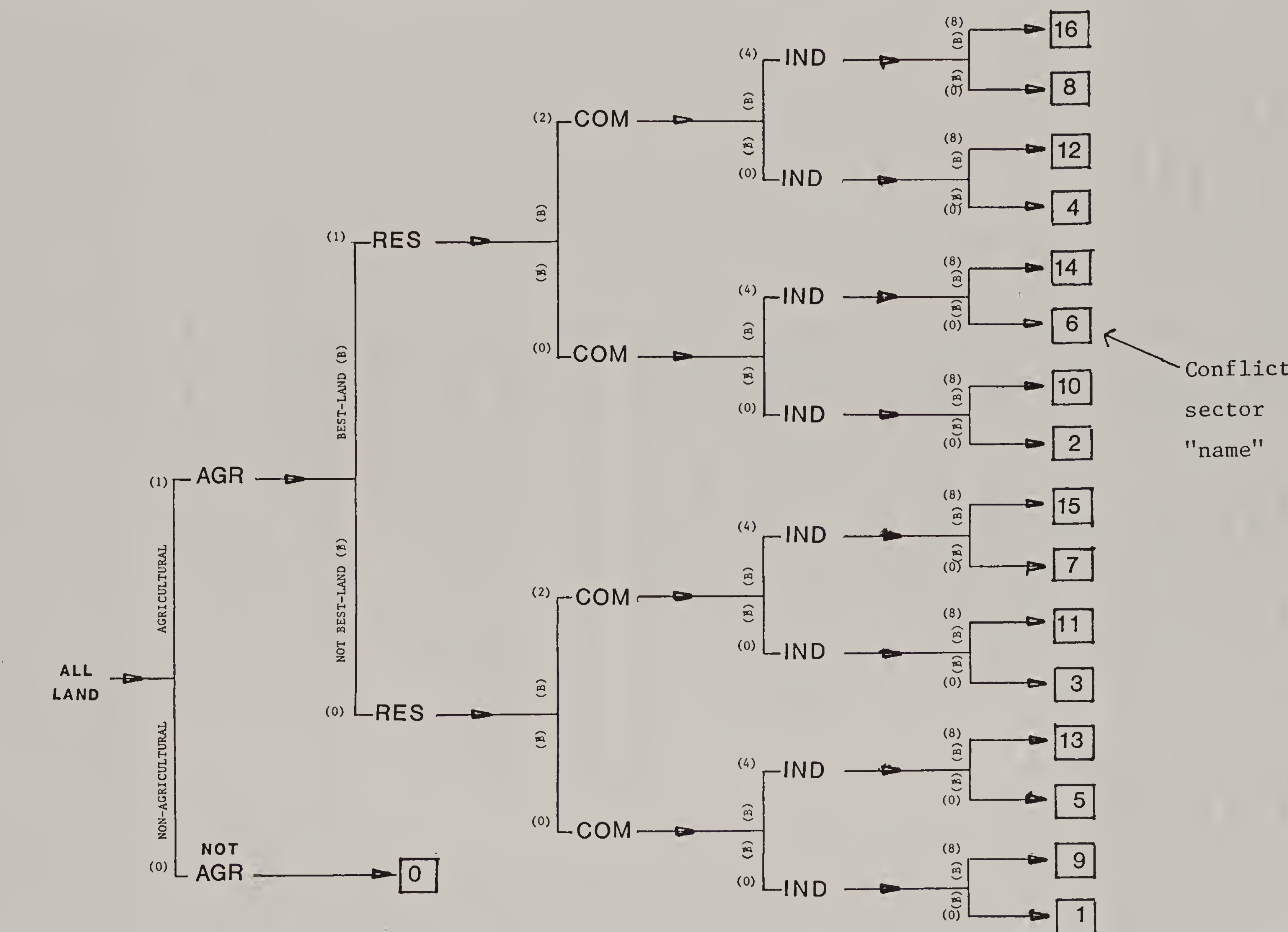

Figure 12--Decision tree for assigning each mapel to a conflict category

Each of the individual categories represented in Figure 11 is listed in Table 6. A description of each category and an acreage estimate are also shown in this table. The actual geographic distribution of these categories is partially explored in Figure 13. Conflict between the best-land for one, two, or three urban uses and each of the two categories of agricultural quality are described on this map. The computer file, which was interpreted to produce this map, retains all 17 distinctions. This file may be displayed as maps in other ways to clarify the distribution of conflict or to emphasize the location of specific categories of conflict.

Table 6--Acres of Lancaster County Assigned to Various Conflict Categories

Conflict Category -identifier-	Tag I C R A*	Description	Approximate Area -acres-
0		Non-agricultural land (not evaluated)	179,300
1	_ _ _ _	Lesser quality agricultural land not in conflict with other uses	138,500
2	_ _ _ X	Better quality agricultural land not in conflict with other uses	263,200
3	_ _ X _	Better quality residential land coincident with lesser quality agricultural land	9,700
4	_ _ X X	Better quality residential land coincident with better quality agricultural land	7,700
5	_ X _ _	Better quality commercial land coincident with lesser quality agricultural land	500
6	_ X _ X	Better quality commercial land coincident with better quality agricultural land	1,000
7	_ X X _	Better quality commercial and residential land coincident with lesser quality agricultural land	300
8	_ X X X	Better quality commercial and residential land coincident with better quality agricultural land	300
9	X _ _ _	Better quality industrial land coincident with lesser quality agricultural land	200
10	X _ _ X	Better quality industrial land coincident with better quality agricultural land	200
11	X _ X _	Better quality industrial and residential land coincident with lesser quality agricultural land	300
12	X _ X X	Better quality industrial and residential land coincident with better quality agricultural land	100
13	X X _ _	Better quality industrial and commercial land coincident with lesser quality agricultural land	300
14	X X _ X	Better quality industrial and commercial land coincident with better quality agricultural land	400
15	X X X _	Better quality industrial, commercial, and residential land coincident with lesser quality agricultural land	1,100
16	X X X X	Better quality industrial, commercial, and residential land coincident with better quality agricultural land	700
Subtotal			603,800
Water		Not shown on Figure 11	20,800
TOTAL			624,600

*The ICRA tag labels each category concisely. ICRA is an acronym which identifies the following column positions in the tag, from left to right: 1 (I=Industrial), 2 (C=Commercial), 3 (R=Residential), and 4 (A=Agricultural) - or ICRA. Each position in the tag is filled by one of two symbols: "X" or "_", an "underlined X" or an "underlined space". The "X" indicates the presence of better quality land and the "_" of lesser quality land for each land use position in the tag. This ICRA tag gives the reader a rapid means for identifying conflict categories which satisfy a specific criterion. For example, if one wants to find all conflict categories for which two urban uses are in conflict with lesser quality agricultural land, he can quickly scan the tags for any with two "X's" in any of the first three positions:

_ X X _
X _ X _
X X _ _

These conditions are satisfied by conflict categories 7, 11, and 13, respectively.

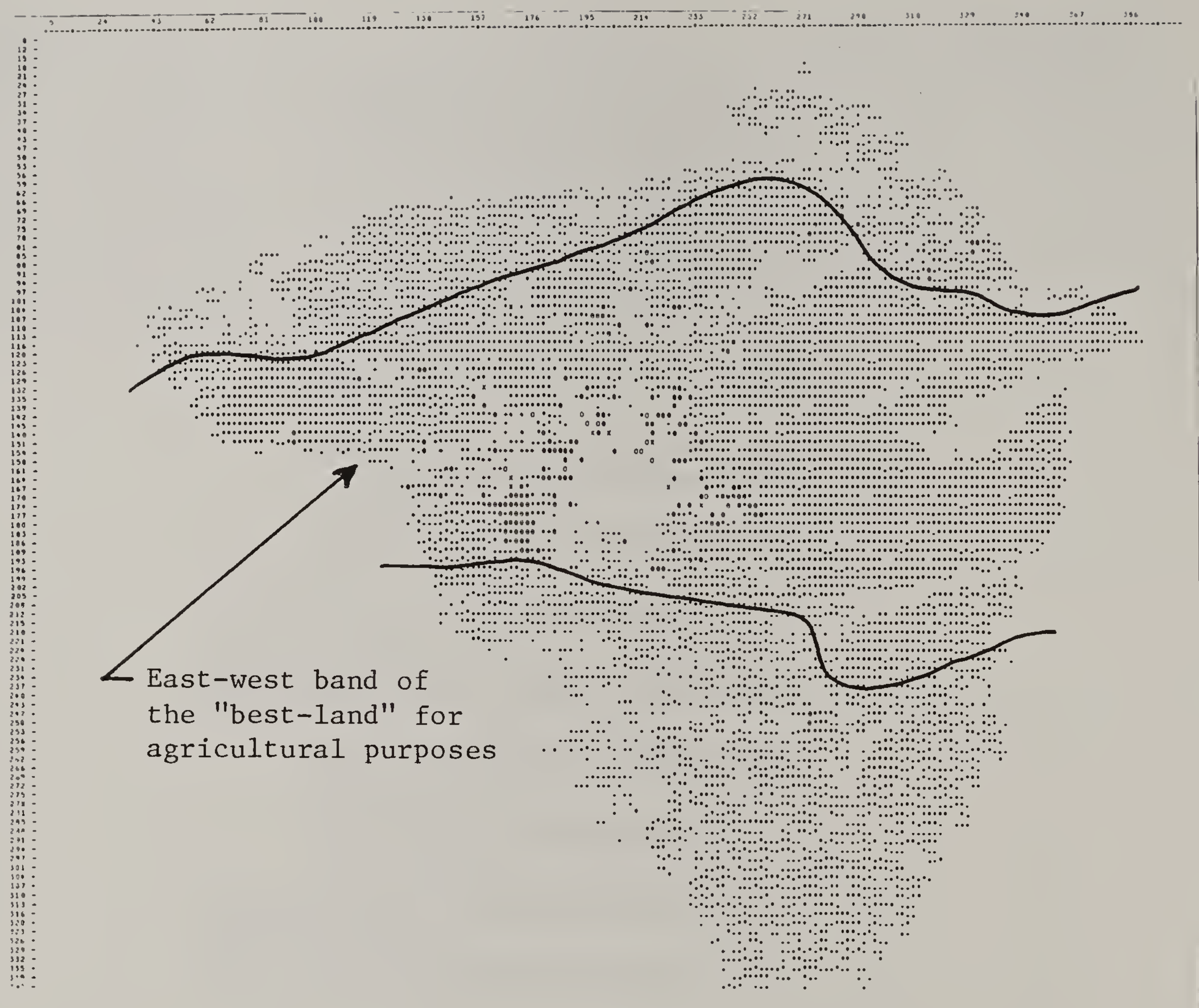

Figure 13-- Geographic distribution of possible conflicts in the urban use of agricultural land

Legend

CONFLICT COMBINATIONS (2X2X2X2=16 COMBINATIONS)

..	1	- NO CONFLICT WITH 2ND BEST AGLAND
••	2	- NO CONFLICT WITH BEST AGLAND
++	3 5 9	- CONFLICT OF 2ND BEST WITH ONE URBAN USE
XX	7 11 13	- CONFLICT OF 2ND BEST WITH TWO URBAN USES
OO	15	- CONFLICT OF 2ND BEST WITH THREE URBAN USES
BB	4 6 10	- CONFLICT OF BEST WITH ONE URBAN USE
▮▮	8 12 14	- CONFLICT OF BEST WITH TWO URBAN USES
▮▮	16	- CONFLICT OF BEST WITH THREE URBAN USES

Scale 1:555,000
Lancaster County
Pennsylvania

III - CONCLUSIONS

For the specific amounts of land use change examined in this report, the agricultural area of Lancaster County will not be altered radically in the next few decades. Much of the change can be expected to occur around Lancaster City which is presently providing a strong focus for urban development. This result compares favorably with the Lancaster County Comprehensive Plan and suggests that computer assisted methods can be used effectively to keep such plans current.

Although this "tight" pattern of land use change appears reasonable, one must not forget that transportation networks (rail and highway), proximity to existing development, and zoning are major determinants of this pattern. All of these determinants are subject to change and their area of influence may be altered as a consequence of the change they themselves induce. It is for this reason that a major purpose of this paper is the description of a method, which may be used in conjunction with the computer information retrieval system, for continuing to monitor and anticipate the implications of these changes.

The agricultural evaluation suggests at least two regions in which the county has large blocks of qualitatively better land (Figure 7, page 27). Both of these can be better defined for planning purposes by studying the computer stored datebase through a series of maps at larger scales. The southern portion of the county, largely because of the nature of the terrain, may not show blocks of land which are as large. There are, however, obvious spots of better quality farmland scattered throughout this southern area.

The conflict evaluation offers few revelations (Figure 13). One possible exception is an area west of Lancaster City which can be traced to a high potential for residential development; this is most probably due to the zoning definition in Manor Township. If this potential residential demand (acres of new housing development) is not absorbed in this Manor Township locality, its redistribution to other areas can be anticipated with the methods and data developed in this report.

An east-west band through the center of the county has been delineated on Figure 13. This band contains most of the best agricultural land and about 60% of all the agricultural land of Lancaster County. Much of this area is strongly influenced by Lancaster City. If the city did not act as a strong and attractive center for new development, the consequences of unfocused growth could undoubtedly be more significant for the best of the agricultural area.

IV - BEYOND THE METHOD

This evaluation has taken longer than is necessary to reach conclusions concerning the two questions asked in the INTRODUCTION to this report. This has resulted from the author's intention to provide sufficient experience and documentation to serve Lancaster County beyond the brief term of this study.

To develop the capability to retrieve geographic information has been a secondary objective of this study. The creation of a geographic information retrieval system* on the Lancaster County UNIVAC computer is one component of this capability. By examining some concerns about land use change, we have demonstrated the use of the information retrieval system as a part of a more general evaluation system (Table 7). Know-how and experience are the other important components of this capability which the Lancaster community should continued to acquire.

At the risk of being redundant, we have worked methodically since June, 1981 with the sponsor appointed Task Force** to develop understanding and clarify issues related to the use of this information retrieval system. We have taken this time-consuming approach for a number of reasons.

First, as was noted in the PREFACE, what we are attempting to do is very speculative. The answer to our questions about future land use change and its consequence for agriculture are beyond what anyone can know with great assurance. The specific nature of our answers depends very much on how we have reasoned our way to them. To appreciate the meaning and significance of the result requires, therefore, an understanding of the method which produced it.

Because our vision dims significantly as we peer farther into the future, the speculative nature of our result for the long term is easily many times greater than for the short run. Therefore, the real value of the evaluation system lies in its reuse as a navigational device rather than a means for specifying destinations. Comprehensive plans serve a similar purpose.

The participation of the Task Force was valued for the knowledge and experience its members contributed. They brought significant insight and guidance to understanding the process of land use change as it occurs in Lancaster County. The reasonableness of our results rests largely on their thoughtful contributions to this effort.

Finally, even though the hands-on use of computers is beyond the expertise of most of us, we should not fail to appreciate the significant role that we

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*Installation of computer programs and data files has been accomplished by DATAMAP under contract with Soil Conservation Service, USDA.

**Members and contributors to this work are listed in Exhibit A at the end of this report.

Table 7--Evaluation System Components and Functions

Components	Role	Functions
Sponsor designated Task Force	Questioner Decision-maker	Develop ideas, formulate questions, define problems, make requests to clarify understanding, etc.
Lancaster County Planning Commission	Technical Planning Advisor	Provide guidance to Task Force, formulate requests for retrieval system, submit requests to Data Processing Department
Lancaster County Data Processing Department	Technical Computer-use Advisor	Operate computer, provide technical advice and assistance (programming) to Planning Commission, overcome technical problems or identify their causes
UNIVAC 90/30 Operating System	Machine (Hardware)	Process code in standard format; calls on information retrieval programs and processes data as directed by retrieval system programs
Computer Information Retrieval System	Programs* (Software)	Perform set procedures stored in code as directed by computer through requests passed on in coded form
Digitized maps and other lists of associated names and numbers	Data	Store, in computer readable form, maps and other data needed by programs

*Programs are documented in a user manual prepared by Datamap, the contractor who wrote and installed the software for the information retrieval system.

must play if computers are to be used intelligently. A functioning information retrieval system consists of more than the computing machine (hardware), the logic coded into computer programs (software), and stored names or numbers (data). Table 7 emphasizes that a functioning system has important human components which:

1) decide when issues are complex enough to require the use of a computer

2) ask relevant questions

3) make value judgments

4) formulate the questions and values so the computer can process them

5) review and discuss the results to determine their reasonableness

6) decide if any of the above steps need to be repeated

7) use the insight derived to make more informed decisions

The hardware, software, and data components of a computer system cannot decide genuine questions of value; they can only use human values to perform tedious and time-consuming tasks quickly and accurately. In this sense they free us to examine these values more carefully.

EXHIBITS

Exhibit A

Task Force Participants

LANCASTER AREA LAND AND WATER RESOURCES STUDY
TASK FORCE PARTICIPANTS

APPOINTED MEMBERS

Chairman - Amos H. Funk,
Lancaster Conservation District

Vice Chairman - Edward C. Goodhart, III
Lancaster County Association of Township Elected Officials

Garth D. Becker -	Lancaster Chamber of Commerce and Industry Alternate: Earl S. Bauder
Jacob R. Bowers -	Pennsylvania Power and Light Company Alternate: Wim Shoonhoven
Darvin Boyd -	Hamilton Bank Alternate: Paul Whipple
Sandy Coyman -	DeVitry, Gilbert, Bradley & Ram Architects
William Forrey -	Lancaster County Developers Association Alternate: Clifford Huffman
Anthony Grano -	Economic Research Service, USDA Alternate: Harold H. Taylor
Elam Herr -	PA Township Supervisors Association
James E. Huber -	Lancaster County Board of Commissioners
Jay Irwin -	Penn State Cooperative Extension Service Alternate: Arnold Lueck
Arthur E. Kurtz -	Sewer and Water Advisory Committee Alternate: Henry C. Brown
P. Craig Lenhard -	Lancaster City Bureau of Planning Alternate: Paula Robinson
Forney Longenecker -	Farmers Union Alternate: Abe Witmer
Robert L. Miley -	Forest Service, USDA
Graham R. Munkittrick -	Soil Conservation Service, USDA Alternate: John J. Mank
Earl Newcomer -	Lancaster County Farmers Association Alternate: James Kreider

Nancy M. Puffer -	Lancaster County Planning Commission
Donald Ranck -	Paradise Township Planning Commission Alternate: Donald Kauffman
K. L. Shirk, Jr. -	Land Use Advisory Committee Alternate: William C. Crosswell

OTHER PARTICIPANTS

John Ahlfeld -	Lancaster County Planning Commission
Leo Grasser -	Lancaster County Assessments Office
Tom Johnston -	Lancaster Conservation District
Frank Lucas	Soil Conservation Service
Jim Mays -	Soil Conservation Service
Bob Scheaffer -	Lancaster County Assessments Office
Dave Watts -	Lancaster County Agricultural Preserve Board

TECHNICAL SUPPORT

Madeline DeStefano	Northeast Technical Service Center, SCS
Ben Germana -	Northeast Technical Service Center, SCS
Ken LeFever -	Lancaster County Data Processing Department
William Murphy -	DATAMAP
Ray Pickering -	Lancaster County Planning Commission
Robert Schoch -	Lancaster County Planning Commission
Scott Standish -	Lancaster County Planning Commission
John Wenderoth -	Economic Reserarch Service

Exhibit B

Evaluation Maps

These maps have been prepared at a somewhat larger scale than those which accompany the text (approximate scale is 1:364,000). However, they are otherwise identical with the last illustration of each map presented in the text. These copies have been included here so that the reader may remove them for side-by-side comparison.


DISTRIBUTION OF EVALUATION SCORES
FOR AGRICULTURAL USE
LEGEND
: Fair
++ Good
OO Better
■■ Best

Figure 8B


DISTRIBUTION OF EVALUATION
SCORES FOR URBAN LAND USES
(INDUSTRIAL)
LEGEND
:: Fair
++ Good
00 Better
■■ Best

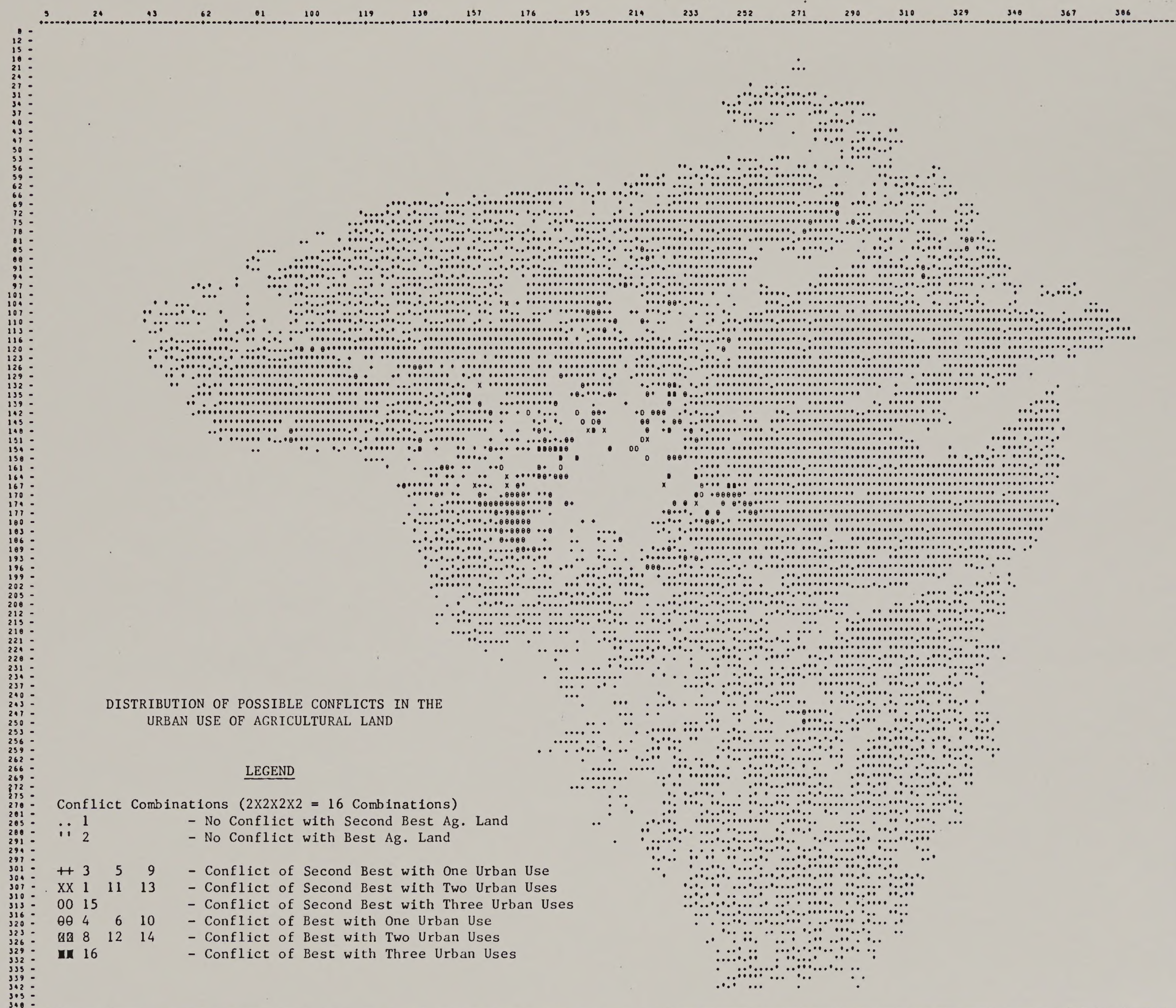
Figure 9 (top)

Figure 9 (center)

Figure 9 (bottom)


POSSIBLE DISTRIBUTION OF FUTURE LAND USES
LEGEND
Land Remaining in Agriculture
Converted to Residential Use
00 Converted to Commercial Use
Converted to Industrial Use

Figure 10



DISTRIBUTION OF POSSIBLE CONFLICTS IN THE
URBAN USE OF AGRICULTURAL LAND

LEGEND

Conflict Combinations (2X2X2X2 = 16 Combinations)

..	1			- No Conflict with Second Best Ag. Land
''	2			- No Conflict with Best Ag. Land
++	3	5	9	- Conflict of Second Best with One Urban Use
XX	1	11	13	- Conflict of Second Best with Two Urban Uses
00	15			- Conflict of Second Best with Three Urban Uses
θθ	4	6	10	- Conflict of Best with One Urban Use
⊠⊠	8	12	14	- Conflict of Best with Two Urban Uses
■■	16			- Conflict of Best with Three Urban Uses

Figure 13